

## **A.2 Guidance on the use of radiation test sites**

For measurements involving the use of radiated fields, use may be made of a test site in conformity with the requirements of clause A.1. When using such a test site, the following conditions should be observed to ensure consistency of measuring results.

### **A.2.1 Measuring distance**

Evidence indicates that the measuring distance is not critical and does not significantly affect the measuring results, provided that the distance is not less than  $\lambda/2$  at the frequency of measurement, and that the precautions described in this annex are observed. Measuring distances of 3 m, 5 m, 10 m and 30 m are in common use in European test laboratories.

### **A.2.2 Test antenna**

Different types of test antenna may be used, since performing substitution measurements reduces the effect of the errors on the measuring results.

Height variation of the test antenna over a range of 1 m to 4 m is essential in order to find the point at which the radiation is maximum.

Height variation of the test antenna may not be necessary at the lower frequencies below approximately 100 MHz.

### **A.2.3 Substitution antenna**

Variations in the measuring results may occur with the use of different types of substitution antenna at the lower frequencies below approximately 80 MHz. Where a shortened dipole antenna is used at these frequencies, details of the type of antenna used should be included with the results of the tests carried out on the test site. Correction factors shall be taken into account when shortened dipole antennas are used.

### **A.2.4 Artificial antenna**

The dimensions of the artificial antenna used during radiated measurements should be small in relation to the sample under test.

Where possible, a direct connection should be used between the artificial antenna and the test sample. In cases where it is necessary to use a connecting cable, precautions should be taken to reduce the radiation from this cable by, for example, the use of ferrite cores or double screened cables.

### **A.2.5 Auxiliary cables**

The position of auxiliary cables (power supply and microphone cables etc.) which are not adequately decoupled, may cause variations in the measurement results. In order to get reproducible results, cables and wires of auxiliaries should be arranged vertically downwards (through a hole in the non conducting support).

## **A.3 Further optional alternative indoor test site using an anechoic chamber**

For radiation measurements, when test frequency of the signals being measured is greater than 30 MHz, use may be made of an indoor test site being a well-shielded anechoic chamber simulating a free space environment. If such a chamber is used, this shall be recorded in the test report.

The test antenna, measuring receiver, substitution antenna and calibrated signal generator are used in a way similar to that of the general method, Subclause A.1. In the range 30 MHz to 100 MHz, some additional calibration may be necessary.

An example of a typical measurement site may be an electrically shielded anechoic chamber being 10 m long, 5 m broad and 5 m high. Walls and ceiling should be coated with RF absorbers of 1 m height. The base should be covered with absorbing material 1 m thick, and a wooden floor, capable of carrying test

equipment and operators. The construction of the anechoic chamber is described in the following subclauses.

#### A.3.1 Example of the construction of a shielded anechoic chamber

Free-field measurements can be simulated in a shielded measuring chamber where the walls are coated with RF absorbers. Figure A.3 shows the requirements for shielding loss and wall return loss of such a room. As dimensions and characteristics of usual absorber materials are critical below 100 MHz (height of absorbers < 1 m, reflection attenuation < 20 dB) such a room is more suitable for measurements above 100 MHz. Figure A.4 shows the construction of an anechoic shielded measuring chamber having a base area of 5 m by 10 m and a height of 5 m.

Ceilings and walls are coated with pyramidal formed RF absorbers approximately 1 m high. The base is covered with absorbers forming a non-conducting sub-floor or with special ground floor absorbers. The available internal dimensions of the room are 3 m x 8 m x 3 m, so that a maximum measuring distance of 5 m length in the middle axis of this room is available.

At 100 MHz the measuring distance can be extended up to a maximum of 2λ.

The floor absorbers reduce floor reflections so that the antenna height need not be changed and floor reflection influences need not be considered.

All measuring results can therefore be checked with simple calculations and the measurement uncertainties have the smallest possible values due to the simple measuring configuration.

#### A.3.2 Influence of parasitic reflections in anechoic chambers

For free-space propagation in the far field condition the correlation  $E = E_0 (R_0/R)$  is valid for the dependence of the field strength  $E$  on the distance  $R$ , whereby  $E_0$  is the reference field strength in the reference distance  $R_0$ .

It is useful to use this correlation for comparison measurements, as all constants are eliminated with the ratio and neither cable attenuation, nor antenna mismatch, or antenna dimensions are of importance.

Deviations from the ideal curve can be seen easily if the logarithm of the above equation is used, because the ideal correlation of field strength and distance can then be shown as a straight line and the deviations occurring in practice are clearly visible. This indirect method more readily shows the disturbances due to reflections and is far less problematical than the direct measurement of reflection attenuation.

With an anechoic chamber of the dimensions suggested in Subclause A.3 at low frequencies up to 100 MHz, there are no far field conditions and therefore reflections are stronger so that careful calibration is necessary; in the medium frequency range from 100 MHz to 1 GHz the dependence of the field strength on the distance meets the expectations very well.

#### A.3.3 Calibration of the shielded RF anechoic chamber

Careful calibration of the chamber shall be performed over the range 30 MHz to 1 GHz.

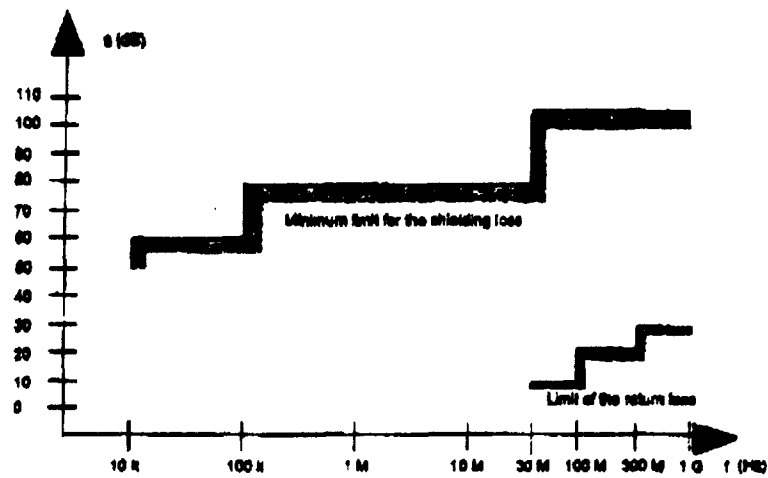
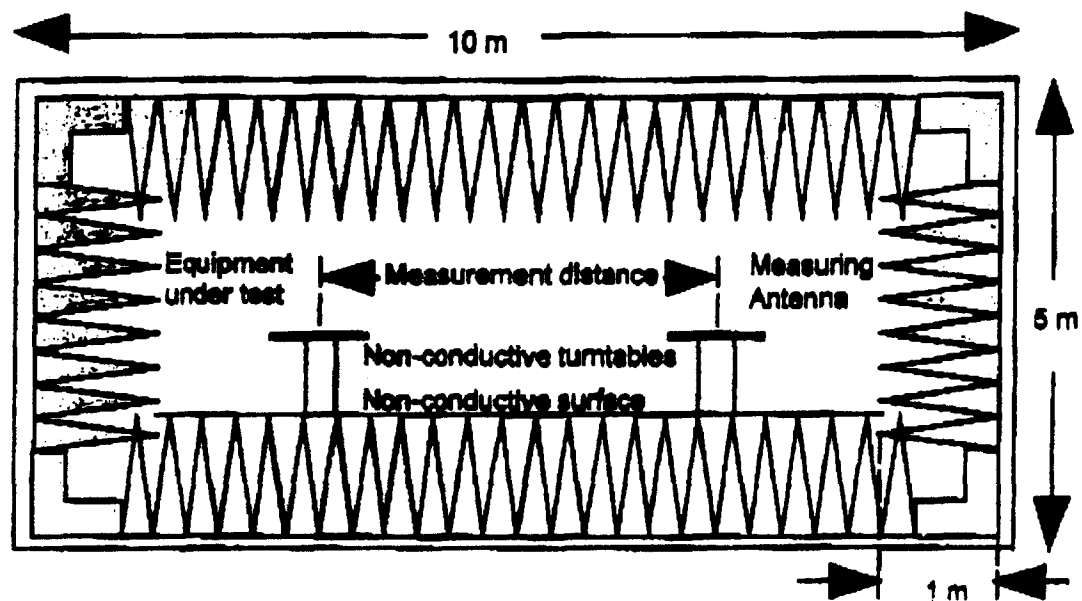


Figure A.3: Specification for shielding and reflections



Ground plan

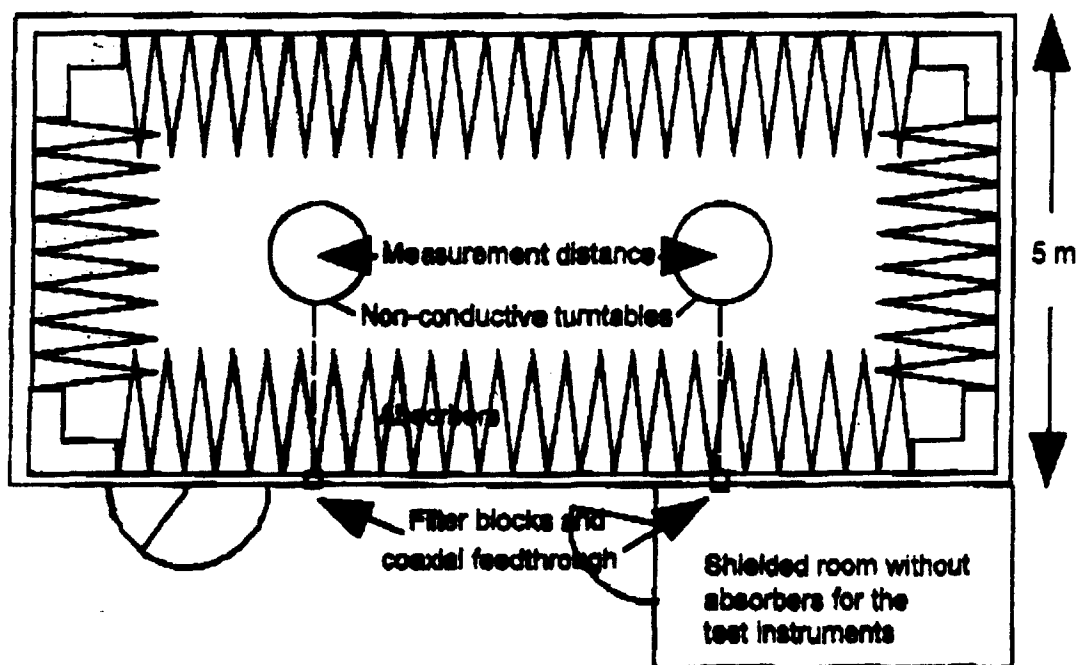


Figure A.4: Example of construction of an anechoic shielded chamber

Annex B (normative): Transmitter carrier limits, radiated H-Field @ 10 m and 30 m distance

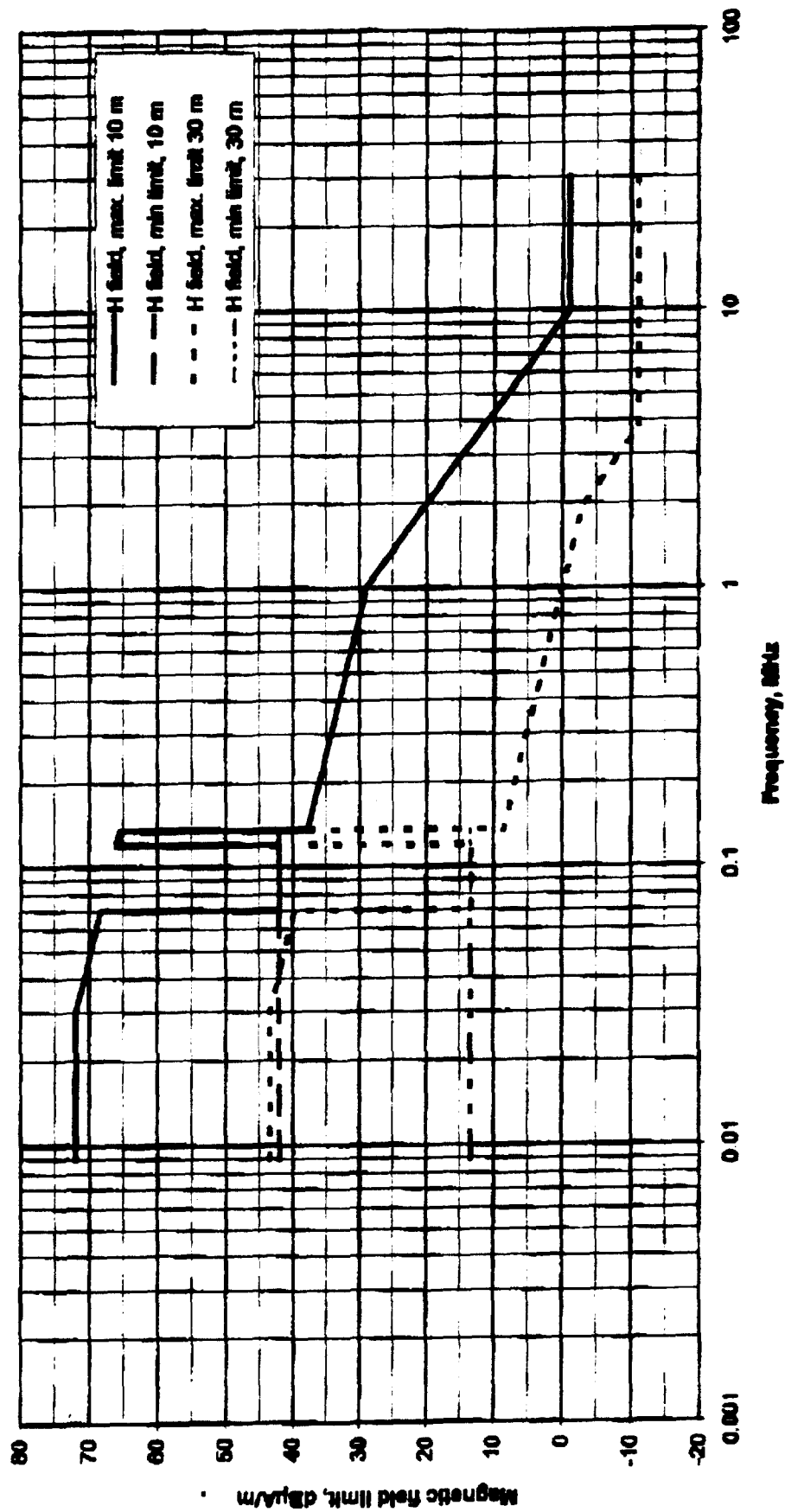


Figure B.1.

Annex C (normative): Transmitter RF carrier current limit for large size loop

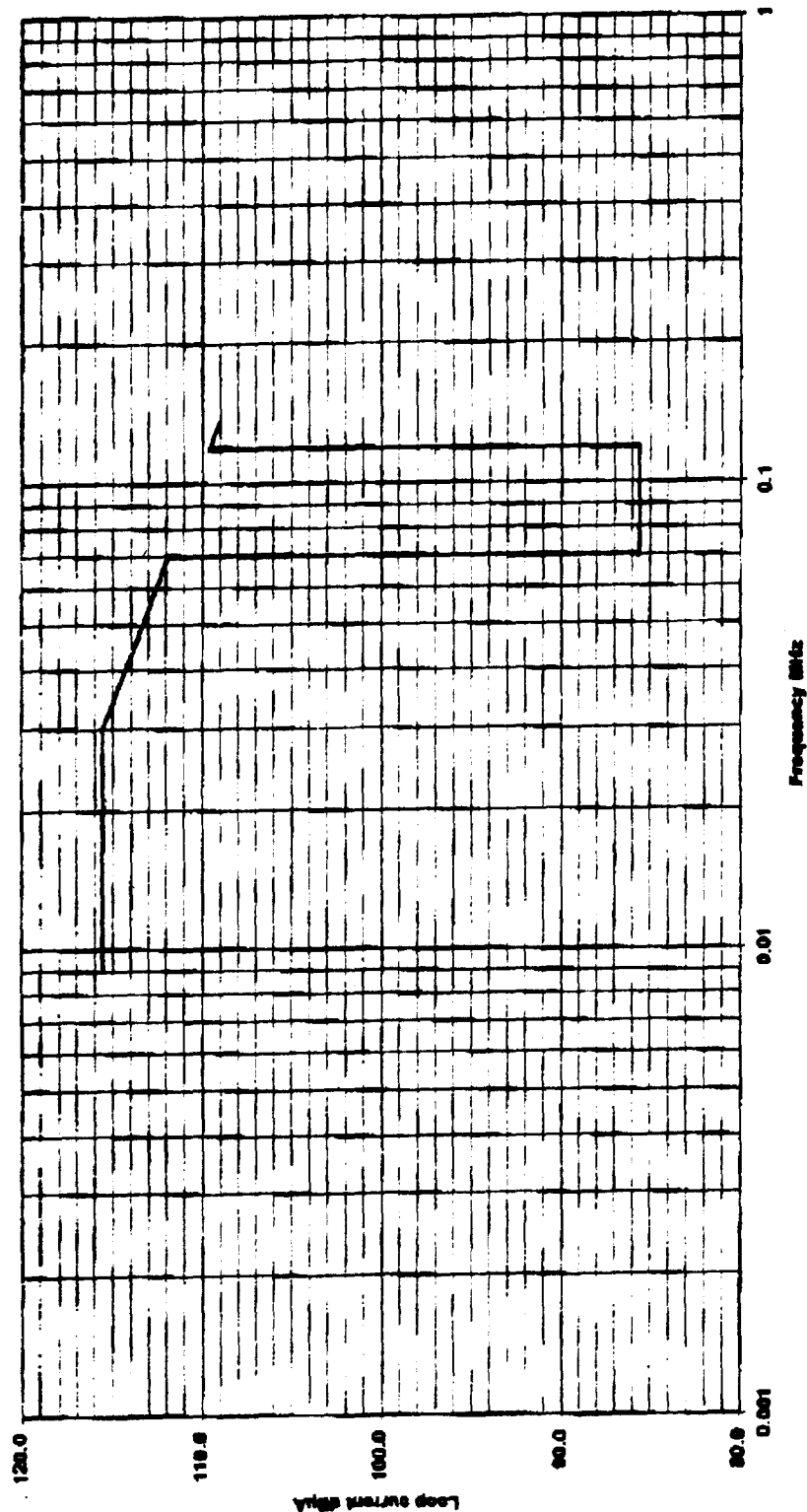


Figure C.1

Annex D (normative): H-field limit correction factor for generated E-fields

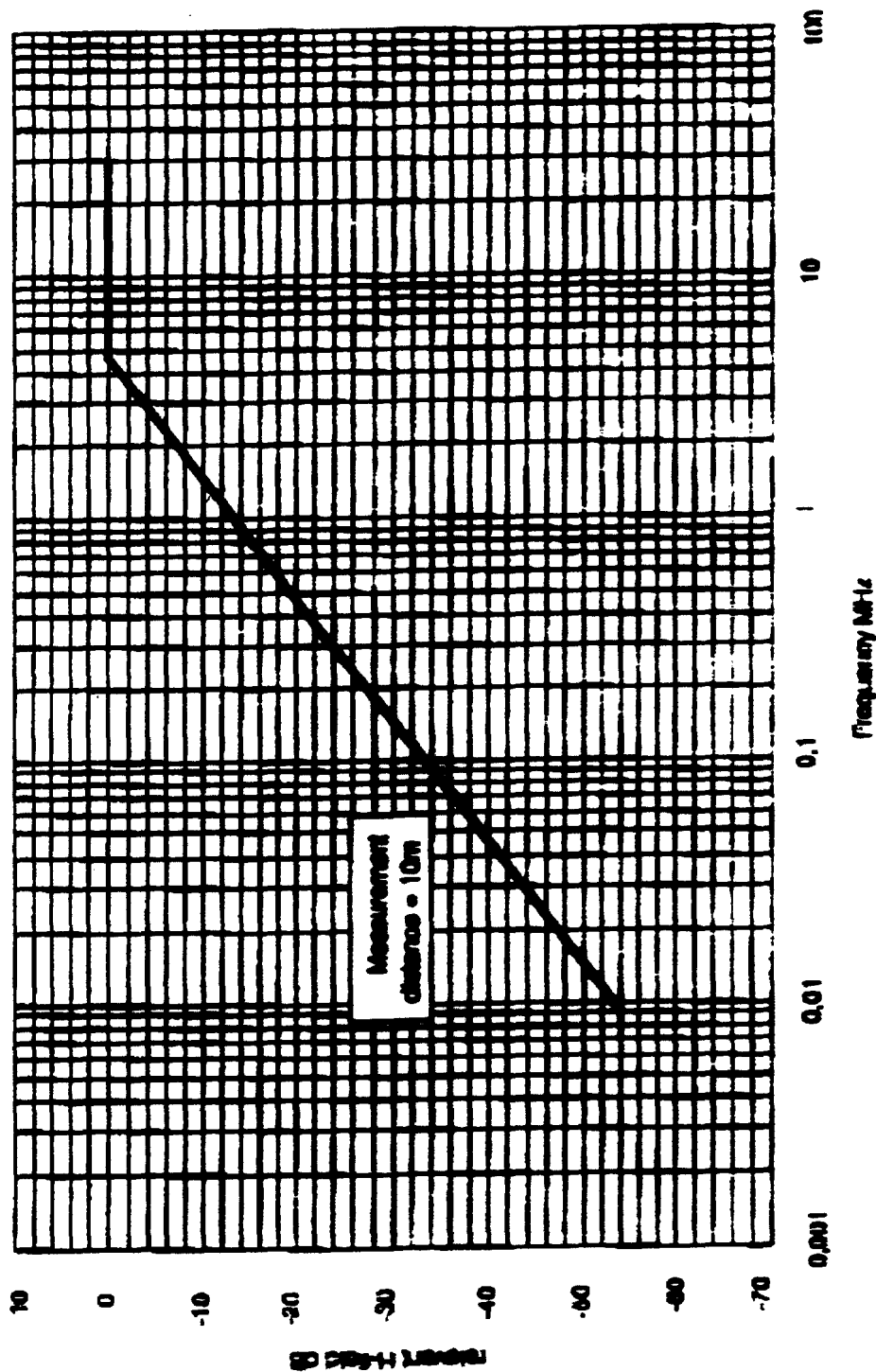


Figure D.1

**Annex E (normative): Spurious limits, radiated H-field at 10 m distances**

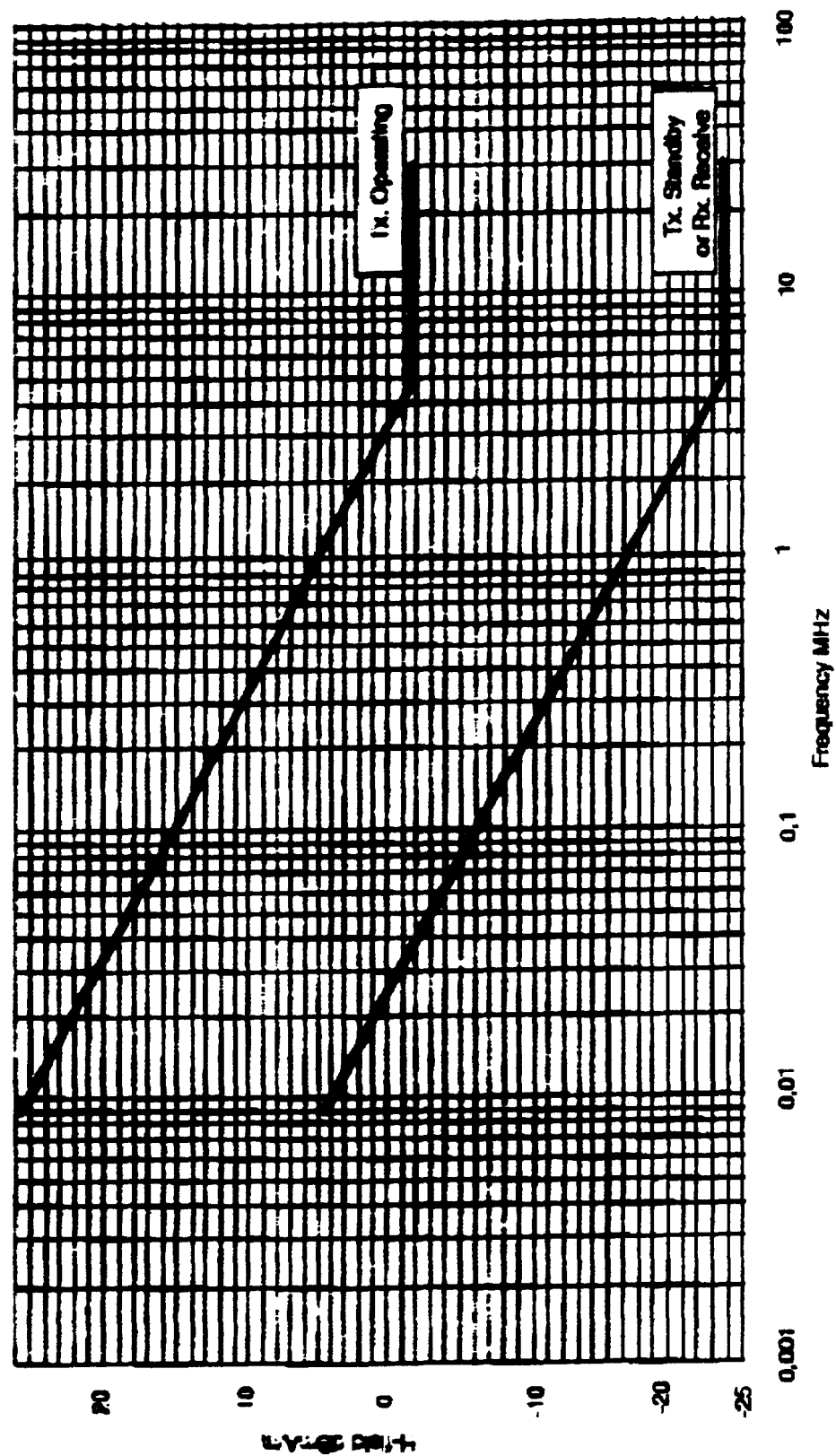


Figure E.1



# **Annex F (normative): Test fixture for measuring inductive transmitter carrier and harmonic currents by use of an artificial antenna**

The artificial antenna is used for equipment with an antenna connector and submitted for type testing without an antenna. The measurement is to determine the RF carrier current and spurious currents in the artificial antenna as the radiated fields for the carrier and spurious which are proportional to the carrier and spurious currents.

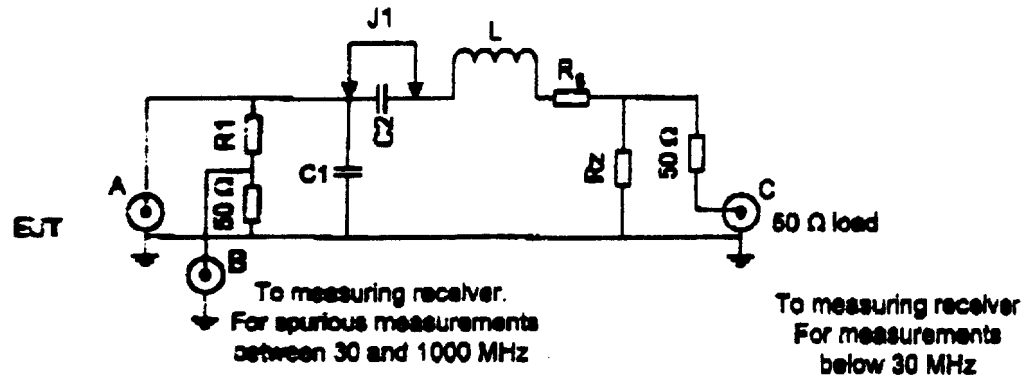


Figure F.1.

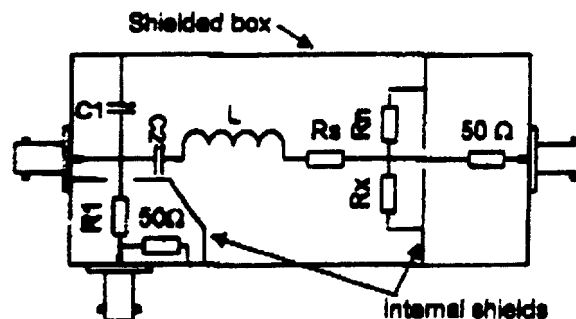


Figure F.2.

An example of the mechanical layout and the equivalent electric circuit of the components are given in figures F.2 and F.1 respectively.

$L$  is the equivalent loop antenna inductance.

If the manufacturer uses several values of antenna inductance two artificial antennas having maximum and minimum inductance  $L$  must be supplied as agreed with the accredited test laboratory. This fact shall be stated in the test report.

$R_1$  and  $R_2$  are low value resistors in parallel to provide a low value inductance free resistor  $R_2$ . The voltage across  $R_2$  is proportional to the conducted carrier and spurious loop currents. These can be measured at connector C.

$R_1$  insure in combination with  $R_2$  identical Q for the artificial antenna and the actual loop antenna.

Resistor  $R_1$  provides together a 50 Ω resistor an attenuation of EUT output signal at connector B used for conducted spurious measurements between 30 MHz and 1 GHz.

Capacitors C1, C2 and connection J1 are optional components to be used as appropriate by the manufacturer to match the actual EUT circuit configuration, for examples see figure F.3 below. Optional configurations of figure F.1 are shown in figure F.3 below:

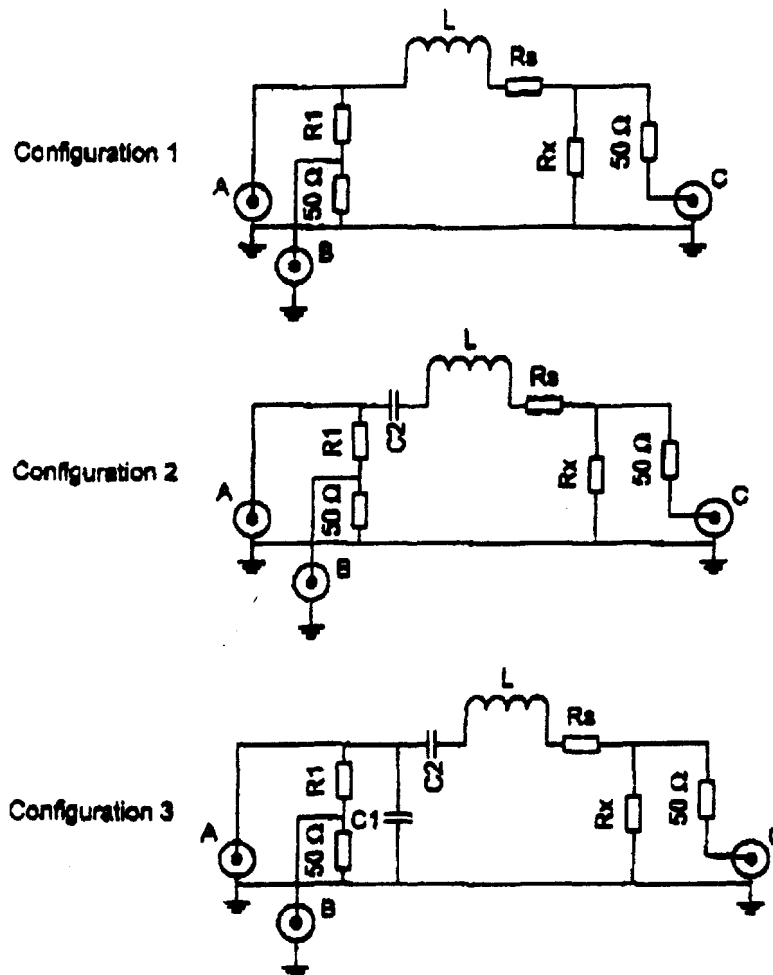


Figure F.3.

The test fixture configuration used by the manufacturer shall be stated in the application and test report.

## Annex G (Informative): E-fields in the near field at low frequencies

E-field at low frequencies is often in the near field and it is in reality only possible to measure with the shielded loop antenna; in this case there is also a relation between the E-field and the H-field by the wave impedance  $Z$ . In the near field the wave impedance is highly dependent on the type of radiating antenna (loop or open end wire) and the wavelength. If the power density at a certain distance is the same for a H-field and an E-field generated signal, the following calculation can be made:

In the direction of maximum power in the near field, the power density  $S$  is:

$$S = \frac{E^2}{Z_e} = H_e^2 Z_e = H_m^2 Z_m \quad (1)$$

where:

$S$  = power density;  
 $E$  = electrical field generated by an E-field antenna at distance  $d$ ;  
 $H_e$  = magnetic field generated by an E-field antenna at distance  $d$ ;  
 $H_m$  = magnetic field generated by a H-field antenna at distance  $d$ ;  
 $Z_e$  = wave impedance of a field generated by an E-field antenna at distance  $d$ ;  
 $Z_m$  = wave impedance of a field generated by an H-field antenna at distance  $d$ .

$$Z_m = Z_0 2\pi \frac{d}{\lambda} \quad \text{if } d < \frac{\lambda}{2\pi} \text{ (near field)} \quad (2)$$

$$Z_e = Z_0 \frac{\lambda}{2\pi d} \quad \text{if } d < \frac{\lambda}{2\pi} \text{ (near field)} \quad (3)$$

Equation (1) gives:

$$H_e = H_m \sqrt{\frac{Z_m}{Z_e}} \quad (A/m) \quad (4)$$

Equation (2) and (3) into (4) gives:

$$H_e = H_m \frac{2\pi d}{\lambda} = H_m \frac{2\pi d f_c}{300} \quad (5)$$

where  $f_c$  is the carrier frequency in MHz.

For  $2\pi d/\lambda = 1$ ,  $d = 10$  and  $f_c = 4.78$  MHz, and using equation (5), this gives:

$$H_e = H_m \frac{f_c}{4.78} \quad (f \text{ in MHz}) \quad (6)$$

For  $2\pi d/\lambda < 1$  if  $f_c < 4.78$  MHz then equation (5) is valid, (i.e. near field).

For  $2\pi d/\lambda \geq 1$  if  $f_c > 4.78$  MHz then  $H_e = H_m$ , (i.e. far field).

The method allows an electric generated E-field to be measured as a magnetic generated H-field by adding a correction factor derived from (6).

For a graphical representation of the correction factor, see annex D.

## Annex H (informative): Class 2 - customised loop antennas

### H.1 Carrier currents

The radiated magnetic field from a loop coil antenna in the near field is given by:

$$H_{10} = \frac{NIA}{2\pi d^3} \text{ (A / m)} \quad (1)$$

where:

N is the number of turns of the loop coil antenna;  
I is the current in Ampere in the loop coil antenna;  
A is the area in m<sup>2</sup> of the loop coil antenna;  
d is the distance in metre from the transmitter.

The formula is valid at low frequencies under the following conditions:

- Length of the coil wire:  $l < \lambda / 2\pi$
- Distance from coil:  $d < \lambda / 2\pi$

The product of NIA is the magnetic moment of the coil.

Equation (1) gives:

$$M = NIA = H_{10} 2\pi d^3 \text{ (Am}^2\text{)} \quad (2)$$

In this ETS the reference measuring distance d is 10m.

If inserted into (2):

$$M = H_{10} \times 6283 \text{ (Am}^2\text{)} \quad (3)$$

After rearrangement of (3):

$$NA = 6283 \frac{H_{10}}{I} \text{ (turns m}^2\text{)} \quad (4)$$

where:

H<sub>10</sub> is the H-field limit @ 10m in A/m (see subclause 7.1.1);

I is the current limit in ampere of the type testing Class.

Equation (4) is valid up to 1 MHz for a 10 m H-field limit. For frequencies above 1 MHz the limits can be derived from:

$$erp = \frac{8\mu_0 \pi^3 M^2 f^4}{3c^3} \quad (5)$$

Equation (5) after rearrangement:

$$M = \frac{1}{f^2} \sqrt{\frac{3c^3}{8\mu_0 \pi^3} erp} \quad (6)$$

Below 1 MHz the NA limit is determined by equation (4). Above 1 MHz the NA limit is determined by equation (5) and is descending with  $f^2$  or 12 dB/oct.

Equation (2) inserted into (5) and after rearrangement:

$$NA = \frac{1}{f^2 I} \sqrt{\frac{30^3}{8 \mu_0 \pi^3} \text{erp}} \quad (7)$$

For  $\text{erp} = 250 \text{ nW}$  in (7):

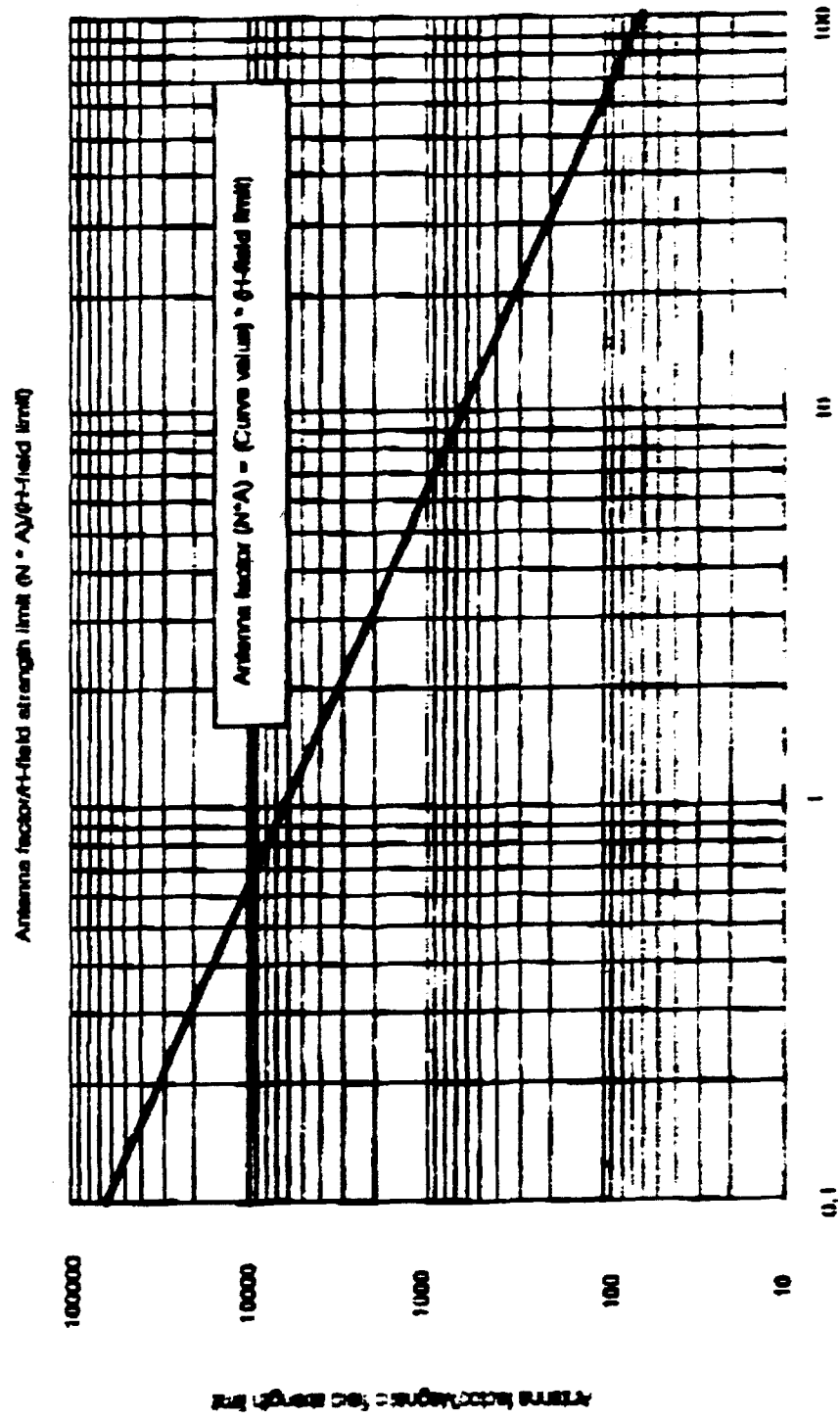
$$NA = \frac{254,9 \times 10^{-3}}{f^2 I} \quad (\text{Am}^2) \quad (8)$$

where:

$I$  is the current limit in ampere of the type testing Class.

$f$  is the frequency in MHz.

For method of measurement for loop current into an artificial antenna. see annex F



Antenna factor/field strength limit (A)

Figure H.1

For type testing of Class 2 equipment, the maximum RF carrier current is stated by the applicant and the minimum NA is determined from figure 4. The minimum value should never be exceeded by the manufacturer when designing customised antennas.

**Annex J (normative): Technical Parameters relevant to the EMC Directive.**

Table J.1. details the parameters in the ETS which is also required to be measured for compliance with the EC Council Directive.

Table J.1.

Clause/ subclause number and title		Corresponding article of Council Directive 89/336/EEC	Qualifying remarks
7.4.	Spurious emissions	4(a)	for transmitters and transceivers
8.1.	Spurious radiations	4(a)	for receivers only



**History**

Document history